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complete denial of the existence of a "time-sense;" that is to say, our estimates of time, short intervals as well as long, are not made by an independent sense, but by more or less completely unconscious observation of internal physiological states, especially muscular tensions. Time judgments rest on a kind of psychic synthesis of the sensations that mark the intervals and those that indicate the state of muscular tension, as visual space judgments on the synthesis of visual and muscular sensations. Take a simple example. The subject is given three distinct sounds, the first and second beginning and ending a standard interval with which the subject is to compare that marked off by the second and third. The entrance of the first sound calls up reflexly an adjustment tension in the muscles of the sense organ, which reaches a maximum and declines. At some stage of the decline the second stimulus enters, causing a renewed tension, followed in turn by a decline like the first. Now, if the third stimulus comes at a stage of decline corresponding to that at which the second came, the interval is pronounced the same; if it comes when the decline is less or greater, the interval is judged shorter or longer than the first. For very brief intervals a similar rôle seems to be played by the sensory "memory-after-image," and for longer ones by the widely irradiated tensions and relaxations accompanying respiration. Into the author's extended exposition of the last, and of the complications introduced into it by attention, etc., we shall not enter here. Suffice it to say, that by his theory he explains the very great variety of "intervals of least error" found by different observers (from .4 sec. to 1.25 sec.), the occasional anomalous series reported by some experimenters, and the striking periodicity of the "intervals of least error" observed by others.

The experimental section (only one fifth of the whole, and then not unduly compressed), presents three series of experiments made upon Münsterberg himself; those made on other subjects are only referred to. They were all made with the time-sense apparatus of Wundt, somewhat bettered, and by the method of average error. In the first series the subject was given two sounds marking an interval (6—60 secs.), and required to make a third when the interval after the second sound had become as great as that before it. When the first two sounds were so given that the second always occurred at the same respiratory phase as the first, the average error was 2.9 per cent.; when this was not regarded, it was 10.7 per cent. In the second series three sounds were given, the first and second beginning and ending the standard interval; and the third, at a varying time from the second, beginning the comparison interval, which the subject observed and closed as before. This time the error, when respiration was regarded, was 5.3 per cent; when it was disregarded, 24.0 per cent. In the third series, Münsterberg consciously withdrew attention from the sensations of tension and relaxation, to the complete confusion of his time-judgments, making 4 seconds seem like 12, and 9 like 3.

Münsterberg is certainly right in looking for the explanation of the "time-sense" in the effect on consciousness of physiological processes, and his contribution is an interesting and suggestive one, especially as regards the discordance of previous experimenters. At the same time most of his experiments have to do with considerable intervals, (his explanation of the judgment of short intervals by tension in the sense organs, is left still in the theoretical stage), and are not numerous nor varied enough to exclude other possible influences in addition to that of respiration.

Schwankungen der Aufmerksamkeit. MÜNSTERBERG. Ibid.

When one attempts to observe a very faint sensation, the barely audible ticking of a watch or the line of separation between the faintest

gray ring of a Masson's disk and the adjacent wholly white one, the sensation comes and goes at somewhat regular intervals. After an experimental study of the phenomenon, N. Lange came to the conclusion that the cause was central and the variation a rhythm of apperception. (*Phil. Studien*, IV, 390 ff.) This view is vigorously attacked by Münsterberg. The experiments upon which he rests his attack were as follows. The subject fixed his eyes and attention on the line of demarkation of a Masson's disk 2 m. distant, and recorded the ebb and flow of sensation by moving with his finger a lever adjusted to write upon a revolving drum, the finger rising as the sensation intensified and falling as it faded, through a period of from 60 to 80 secs. In the first series the average length of time from the beginning of one disappearance to the beginning of the next was 6.9 secs., (Lange, 3.1-3.4) with a mean variation of 1.1 sec. The subject noticed faint sensations of motion in the eyes accompanying the fluctuations. In the next series, prisms were brought before the eyes and removed alternately for periods of two seconds, causing a deviation of the eyes without disturbing the vision of the rings; the result was a lengthening of the period to 12.3 secs. Voluntary closure of the eyes every second or two seconds generally prevented the fluctuations, while the interposition of a gray screen before the disk, though interrupting vision for a slightly longer time, increased their rapidity, making them now recur in 5.8 secs. More rapid interposition and removal of the screen caused a lengthening of the periods; and when the disk was covered continuously for a full second out of every four, the continuity of the sensation was broken up and no fluctuations were found. Observations with indirect vision gave a rate of 8.2 secs. Continuous movements of the whole disk up and down or from side to side at the rate of 10 cm. per second, bringing it to its original position every four seconds, caused total suspension of the periodicity. Very rapid breathing quickened it to 5.1 secs.; slow breathing slowed it to 8.5; but the periodicity did not seem causally dependent on respiration. Several of these tests were also tried with similar results by the observation of a black dot on a large white field. The chief points in the interpretation of these experiments, to which a long section is devoted, are as follows. The whole group shows the phenomenon in question to be of peripheral and not central origin, (else why the profound effects of purely peripheral changes?) and in particular from the fatigue of the muscles of fixation and accommodation. The prisms lengthened the period because the deviation of the eyes which they caused relieved the fatigue of fixation and lessened that of accommodation; the winking experiments relieved the latter and so prevented the failure of accommodation, and thereby the disappearance of the demarkation line on the disk. The interposition of the screen had the contrary effect because it did not relieve accommodation, but rather made it more difficult. In a similar way the other experiments support the muscle-fatigue theory; and what is thus demonstrated for the muscles of the eye, Münsterberg carries over to the less accessible muscles of the ear. The experiments form a valuable contribution to the subject and are demonstrative on the point immediately in question, to wit, the very important function of the periphery in the variations of faint visual sensations. Some portions of his critique upon Lange, however, seem to us less sound, and indeed in explaining Lange's experiment with faint stimuli to two senses at once he introduces central processes (in a secondary position, to be sure) not unworthy the name of changes of attention.

Augenmass. MÜNSTERBERG. *Ibid.*

After the usual historical and critical review the author makes preliminary report on the results of a comprehensive study of the conditions